SO_3 Mitigation Strategy Process

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Summary

American Electric Power has developed and implemented a structured, analytical process to determine the most appropriate strategy to proactively mitigate SO_3 emissions. This process is focused on units to be retrofitted with SCR and FGD technologies. This staged approach begins by examining multiple technology options with analytical assumptions based largely on test data. Reduction in creation of SO_3 through optimizing SCR catalyst management is also considered and applicable technologies are screened using worst scenario assumptions. The life-cycle economics of screened technologies are evaluated using baseline assumptions. The result is a unit-specific, least-cost mitigation recommendation to achieve the desired strategy objective.

Currently, electric generating facilities are not subject to specific regulatory SO_3 emission limits. However, SO_3 emissions can impact flue gas plume appearance, increasing attention to plant operations by regulatory agencies and the public. Plume aesthetics are strongly influenced by SO_3 concentrations, but ambient conditions, including temperature, relative humidity, sun position, cloud cover, and the relative position of an observer, can also subjectively impact appearance. Maintaining reduced SO_3 concentrations is a key driver for minimizing plume visibility and associated risks.

To evaluate the theoretical need for SO_3 mitigation a spreadsheet model was developed to calculate the concentration of SO_3 at discrete points of the flue gas stream from the furnace to the stack. For each generating unit, specific data such as design basis gas flow and SO_2 fuel content were incorporated along with assumptions for creation and removal of SO_3 along the flue gas path. Reduction of SO_3 attributable to commercially-available mitigation technologies was optimized to yield a stack concentration of SO_3. The following technologies were considered: wet electrostatic precipitator (WESP); low-conversion SCR catalyst; magnesium hydroxide injection in the boiler; ammonia, hydrated lime, or trona injection in the flue gas duct between the air heater and ESP; and combinations of magnesium hydroxide with ammonia, hydrated lime, or trona.

Baseline operating assumptions derived frombest engineering judgment, flue gas sampling, and operating experience were established for boiler SO_2 to SO_3 conversion rate, air heater H_2SO_4 capture, SCR SO_2 to SO_3 conversion rate, and scrubber H_2SO_4 removal. These assumptions, representing “average” unit operations, were used to perform economic evaluations. Deviations from the baseline assumptions were proposed to evaluate a scenario enveloping the least favorable operating condition to screen viable mitigation technologies, consequently minimizing the volume of economic life-cycle analysis for each unit.

The base case catalyst management plan at each unit was defined as the replacement schedule associated with the original catalyst installation to maintain design basis NO_X performance. Variations of this plan intended to expedite reduction of the SO_2 to SO_3 conversion rate through accelerated replacement of catalyst (and associated financial impacts from unscheduled outages and NO_X performance) with low-conversion type were also developed. These alternative management plans were used to evaluate whether the reduced O&M costs associated with lower sorbent usage for SO_3 mitigation would create superior net present value compared to the original catalyst replacement schedule.

Combinations of technologies/catalyst management plans for which the stack SO3 concentration theoretically achieved the upper limit of the SO_3 target operating range were then subjected to economic analysis. Estimates of technology and catalyst replacement capital costs and O&M expenditures, primarily for mitigation consumables, were established and viable technologies for each unit were compared. Qualitative factors such as technical performance, secondary impacts, and risks were also considered. In general, for the technologies evaluated, economic analysis revealed that additional capital to accelerate catalyst replacement was not sufficiently offset by reduced O&M costs to justify early replacement. Lowering the SO_2 to SO_3 conversion rate across the SCR catalyst through accelerated replacement provided an opportunity to specify multiple sorbent injection technologies – such as magnesium hydroxide with hydrated lime or trona – providing mitigation flexibility as a physical hedge to future volatility in sorbent pricing and supply.

In addition to evaluating the most appropriate mitigation strategy for each unit based on life-cycle economics, the following technical/economic factors were also considered: utilization of existing ammonia injection systems at SCR-equipped units; impact to fly ash sales and disposal (pond chemistry or groundwater impacts); mercury oxidation potential across low-conversion SCR catalyst; injection limits for sorbents considering ESP size and anticipated performance impacts; and flue gas temperature regulation in ducts for corrosion control and/or sorbent deposition.

The analytical process implemented by American Electric Power to determine the most appropriate SO_3 mitigation strategy at its operating units retrofitted with FGD and SCR pollution control technologies provides a consistent, robust approach with meeting the target operating range. The flexibility of having multiple mitigation technologies available ensured that a least-cost life-cycle solution was provided at each unit.